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TITLE: Global Distribution of Tropical Rainfall, Mesoscale Convective Systems and Precipitable Water Using SSM/I and WetNet

FINAL REPORT

A brief Summary of accomplishments under the NASA WetNet Grant, 1994-1996 follows. Additional details can be found in the reviewed literature (listed below), the theses (listed below; copies available on request), or our WetNet Home Page, at
http://www.met.tamu.edu/wetnet.html

1. The vertical profile of radar reflectivity (VPRR) in convective cores within ocean and land mesoscale convective systems (MCSs) has been further quantified. Restivo's MS thesis showed (as have many others) that lightning rate can be well-related to radar reflectivity in the mixed phase region. Many oceanic convective systems simply have updrafts that are too weak to sustain large particles in the mixed phase region, and consequently there is neither high reflectivity nor lightning in many such cloud systems, in spite of large, deep, cold clouds prominent on infrared imagery.

2. All AMPR (Advanced microwave precipitation radiometer) data, and their statistical properties, have been analyzed for the COARE database from each flight of NASA's ER2. Ice scattering at 19 GHz and at 37 GHz is much weaker than for U.S. storms. At 85 GHz, 225°K is now proposed as a convective threshold. For the COARE database, the properties of convective and stratiform regions of MCSs have been contrasted. This work was carried out in partnership with Roy Spencer and Robbie Hood of NASA MSFC and is reported in McGaughey's thesis, McGaughey et al. 1996, and McGaughey and Zipser 1996.

3. We have compared the ice scattering signature at 85 GHz from SSM/I, the radar reflectivity in the mixed phase region from the Houston WSR88D radar, the lightning flash rates from the NLDL (national lightning detection network), and the area of cold cloud tops from GOES IR data, for 9 MCSs in Texas. Close relationships are found except for area of cold clouds. The contrast with COARE systems is marked; for the same "class-4-sized" MCS, Texas systems have 2 orders of magnitude more lightning than systems over the tropoical Pacific. (Toracinta's thesis, Mohr et al., 1996, and Toracinta et al., 1996)

4. Building on the above results, we devised a way to define MCSs by their 85 GHz ice scattering signature, and we have used the F11 SSM/I data for a census of all MCSs between 35°N and 35°S for January, April, July, and October 1993. Our results confirm many conclusions of others but much new has been learned. Land-ocean differences have been quantified. Tropical-subtropical differences have been quantified. Sunrise-sunset differences have been quantified. The geographical distribution of "intense" ice scattering MCSs and IR-defined MCCs (Laing and Fritsch 1996) agrees well. (Karen Mohr Devlin's thesis; Mohr and Zipser 1996a,b)

5. A 16-year daily climatology of precipitable water has been developed from TOVS infrared observations, under partial WetNet support. SSM/I precipitable water estimates have been used to qualify and verify the data set. Collocated TOVS, radiosonde and SSM/I estimates have been intercompared showing good agreement, especially if the microwave estimates are carefully screened (late generation SMMR estimates were only marginally acceptable). In a second comparison, one season of TOVS and SSM/I precipitable water distributions over the tropical Pacific were examined for "significant moisture features." Based on SSM/I, there was an approximate 95% agreement in significant features, with only one day classified as unacceptable. (Yin's thesis, manuscript prepared for J. Climate, awaiting the completion of a companion paper).

6. Also under partial WetNet support and an ongoing NASA Global Program grant, we are examining the use of MSU 1 window channel signals as a measure of "total moisture substance." Radiative transfer modeling has stratified the MSU signal into surface contributions (emissivity and SST changes), vapor signal (SSM/I derived) and cloud liquid water (SSM/I derived). Application of the data set is limited by the sensitivity to surface emissivity, but it delimits ITCZ spatial structure better than any other variable currently available. Application to the east Pacific ITCZ complex reveals the evolution of the southern portion to be a seasonal scale event, strongly interaction with the northern band. (Conference proceedings by Smith; dissertation to be completed.)

7. The evolution of the southeast Pacific ITCZ in 1995 has been documented in SSM/I products and SSM/T-2 channel brightness temperatures. A moisture convergence parameter has been constructed from SST and SSM/I precipitable water, which removes the amount of atmospheric moisture accountable to local thermodynamic equilibrium with the underlying SST. The resultant moisture, accountable to large scale dynamical processes, describes a triple ITCZ structure (northern and southern components and the SPCZ) of near equal magnitude. The active southern ITCZ (defined through the SSM/I) lasts no longer than three weeks. Under other NASA support, this band is defined in T-2 signals to be a synoptically driven complex of mesoscale systems that ultimately is controlled by SST seasonal changes (Conference proceedings and thesis by Serke).

Refereed Publications Resulting from WetNet Support:

McGaughey, G., E.J. Zipser, R.W. Spencer, and R.E. Hood, 1996: High resolution passive microwave observations of convective systems over the tropical Pacific ocean. *J. Appl. Meteor.*, **35**, in press.

McGaughey, G., and E.J. Zipser, 1996: Passive microwave observations of the stratiform regions of two tropical oceanic mesoscale convective systems. *J. Appl. Meteor.*, **35**, in press.

McGuirk, J.P., M. Yin and S. Schroeder, 1996: Statistical estimation of precipitable water from NOAA TOVS observations, to be submitted to *J. Climate*.

Mohr, K.I., E.R. Toracinta, E.J. Zipser, and R.E. Orville, 1996: A comparison of WSR 88D reflectivities, SSM/I brightness temperatures, and lightning for mesoscale convective systems in Texas. Part 2: SSM/I brightness temperatures and lightning. *J. Appl. Meteor.*, **35**, 919-931.

Mohr, K.I., and E.J. Zipser, 1996a: Defining mesoscale convective systems by their ice scattering signature. *Bull. Amer. Meteor. Soc.*, **77**, 1179-1189.

Mohr, K.I., and E.J. Zipser, 1996b: Mesoscale convective systems defined by their 85 GHz ice scattering signature: Size and intensity comparisons over tropical oceans and continents. *Mon. Wea. Rev.*, **124,** in press.

Toracinta, E.R., K.I.Mohr, E.J. Zipser, and R.E. Orville, 1996: A comparison of WSR-88D reflectivities, SSM/I brightness temperatures, and lightning for mesoscale convective systems in Texas. Part 1: Radar reflectivity and lightning. *J. Appl. Meteor.*, **35**, 902-918.

Theses supported by WetNet:

Devlin, K.I., 1995: Application of the 85 GHz ice scattering signature to a global study of mesoscale convective systems. M.S. Thesis, Dept. of Meteorology, Texas A&M Univ., College Station TX 77843-3150, Aug. 1995, 100 pp.

McGaughey, G.R., 1994: High resolution passive microwave observations of convective systems over the tropical Pacific ocean. M.S. Thesis, Dept. of Meteorology, Texas A&M Univ., College Station TX 77843-3150, Dec. 1994, 84 pp.

Restivo, M.E., 1995: The convective structures associated with cloud to ground lightning in TOGA COARE Mesoscale Convective Systems. M.S. Thesis, Dept. of Meteorology, Texas A&M Univ., College Station TX 77843-3150, Aug. 1995, 98 pp.

Serke, J.D., 1996: Evolution of the Southeast Pacific ITCZ in Boreal Spring as Viewed from SSM/I and SSM/T-2, M.S. Thesis, Department of Meteorology, Texas A&M University, College Station TX 77843-3150, 159 pp.

Toracinta, E.R., 1995: Radar, satellite, and lightning characteristics of select mesoscale convective systems in Texas. M.S. Thesis, Dept. of Meteorology, Texas A&M Univ., College Station TX 77843-3150, Dec. 1995, 70 pp.

Theses, continued

Yin, M., 1994: Information Content and Reliability of TOVS Estimates of Precipitable Water. M.S. Thesis, Department of Meteorology, Texas A&M University, College Station TX 77843-3150, 108 pp.

Conference Proceedings:

McGuirk, J.P., M. Yin, and S.R. Schroeder, 1996: Precipitable water estimation from TOVS, AMS 8th Conf. on Satellite Meteorology and Oceanography, Atlanta, January 1996.

Serke, D.J., and J.P. McGuirk, 1996: Multiple ITCZs in SSM/I and SSM/T-2, *op. cit.*

Smith, D.E.W., and J.P. McGuirk, 1996: Microwave Sounding Unit channel 1 moisture signal over the eastern Pacific Ocean, *op. cit.*

McGuirk, J.P., M. Yin and E.W. Hatfield, 1995: A ten-year climatology of the Pacific ITCZ from TOVS deduced precipitable water, Proc. Amer. Meteor. Soc. 21st Conf. on Hurricanes and Tropical Meteorology, Miami, April 1995.

Smith, D.E.W., and J.P. McGuirk, 1995: Eastern Pacific moisture signal from three NOAA TOVS satellite products, *op. cit.*

McGuirk, 1994: Organization of tropical convection inferred from OLR, MSU, TOVS and SSM/I, (invited paper) 7th AMS Conf. on Satellite Meteorology and Oceanography, Monterey, 1-2.

______, M. Yin and H.S. Chung, 1994: Statistical retrieval of precipitable water from TOVS and OLR, *op. cit.,* 94-95.

______, 1993: A 15-year daily precipitable water climatology form TOVS radiances, 18th NOAA Climate Diagnostics Workshop, Boulder CO, November 1993.